The impact of rectal filling on rectal dose during hypofractionated radiotherapy of the prostate

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INTRODUCTION

Prostate cancer has one of the highest survival rates of all cancers. 58% of patients receive radiotherapy as part of their treatment course, but as many as 50% of them experience negative side effects to the rectum that decrease their quality of life.

Understanding the relationship between radiation doses to the rectum and the severity of toxicities induced in it is crucial in the endeavour to improve radiotherapy outcomes.

OBJECTIVE

Our objective was to quantify the changes in rectal volume and gas levels over the course of radiotherapy in order to determine the strength of the relationship, if any, with the daily variations in rectal dose.

Doing so also allows us to assess the potential merits of a low gas diet regimen for patients.

METHODS / INTERVENTIONS

The rectum was delineated on the planning CT and daily CBCT images of 16 moderate-risk prostate cancer patients who were treated with 60 Gy in 20 fractions. In addition to the rectum, a second rectum structure was defined as the normal rectum truncated to the superior and inferior boundaries of the 48 Gy isodose line.

Images, contours, and dosimetric data for all structures were exported from the treatment planning system. The volume of rectal gas on each day of treatment for each patient was quantified by calculating the number of gaseous voxels in each rectum structure using a custom analysis script. The script makes use of a lookup table to differentiate between materials in the image.

Extracted dosimetric parameters were plotted as a function of volumetric parameters to determine level of correlation using linear least-squares regression. Significant correlations were defined as having $R^2 > 0.6$.

RESULTS

Changes in rectal volume are correlated with changes in rectal gas

The difference between planning and daily treatment volumes were plotted as a function of the difference between daily and planned gas volumes. Significant positive correlation between differences in gas and total volume were found for the full rectum structure ($R^2 = 0.729$, Figure 3), and the truncated rectum structure at the level of the prostate ($R^2 = 0.696$).

Changes in rectal dose are correlated with the differences between individual daily volumes and the volume at the time of planning

The level of correlation between daily fluctuations in the volume of the rectum receiving specific isodose levels and gas/total volume variations was investigated for both the full and truncated rectum structures. The strongest correlations were found to exist at lower isodose levels (Figures 5, 6), whereas correlations at higher isodose levels were not found to be significant. The total volume of the truncated rectum was found to be the strongest predictor of daily dose changes.

PATIENT IMPACT

Our current results suggest that regulating the degree of rectal filling over the course of treatment could reduce fluctuations in daily rectal dose.

Improvement was also observed when using the truncated rectum structure. This was understandable, as changes in positioning at the level of the prostate would be expected to have a greater impact on dose.

CONCLUSION

Variations in daily rectal volumes were found to be correlated with variations in rectal gas volumes over the course of treatment. When rectum exposure at multiple isodose levels was investigated, the portion of exposed rectum was found to be correlated to rectal gas at lower isodose levels, but not at the higher ones that are used as dosimetric constraints.

Patients across all hospitals in the Rossy Cancer Network may benefit by participating in the randomized trial we aim to conduct in the near future. In addition to access to a dietitian over the course of treatment, they will be able to actively participate in research through self-reporting and detailed follow-up appointments, with the potential to reduce their risk of developing radiation toxicities should they successfully follow their diet plans.

REFERENCES

1. Canadian Cancer Statistics 2018. Toronto, ON: Canadian Cancer Society; 2018